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# KOOTENRI RIVER WHITE STURGEON INVESTIGATIONS
# AND EXPERIMENTAL CULTURE

Annual Progress Report FY 1989

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## ABSTRACT

The population of white sturgeon in the Kootenai River has continued to decline since 1983, in spite of a closure to harvest in the U.S. section of the river. Setline and angling techniques were used to sample 228 sturgeon from the river between Kootenai Falls and Kootenay Lake during 1989. Sturgeon were found in Montana within 4 km of Kootenai Falls and downstream from Bonners Ferry, Idaho to Kootenay Lake, British Columbia. Our data indicate there is a complete lack of recruitment of juveniles into the population. The youngest fish sampled was of the 1977 year class, and the population is estimated at 850 individuals with 95% confidence intervals of 574 to 1,463. At present, we do not understand what mechanisms are limiting recruitment.

Over the past 70 years, the lower Kootenai River has been extensively diked for flood control, effectively eliminating backwater and slough areas that may have provided juvenile rearing habitat. Contaminants have entered the river system via mining operations and agricultural practices. In 1972, Libby Dam began operation, reversing the natural flow regime of the river, and releasing frequent power peaking flows.

Of 179 fish that were surgically sexed, 37% were female and 35% were male. Thirty-four percent of the females held developing oocytes. All oocyte samples from nine females contained copper (1.18 to 2.50 µg/g) and zinc (15.6 to 32.8 µg/g). Most samples also contained organochloride residues such as DOT, DDD, DDE, and PCBs (0.215 to 1.080 µg/g, combined). River sediment samples contained 1.62 to 12.8 µg/g copper and 22.4 to 70.6 µg/g zinc, but no organochloride residues.

Electrophoretic analysis of muscle samples indicated reduced heterogeneity compared with lower basin white sturgeon and showed a significantly different degree of variation between the two stocks in seven enzyme systems.

An ongoing sonic telemetry study has revealed definite long distance movements in response to water flow fluctuations. Sturgeon regularly move across the British Columbia-Idaho border and seek out deep holes or migrate to Kootenay Lake during late fall. Adequate ranges in river depth and current velocity allow sturgeon to select for those habitat parameters; however, turbidity and temperature are homogeneous throughout the river at any given time.

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# INTRODUCTION

## Geography

The Kootenai River originates in Kootenay National Park, British Columbia (B.C.), flowing south into Montana, then turning northwest at Jennings, the site of Libby Dam, at river kilometer (rkm) 352.4 (Figure 1). Kootenai Falls, 50 km below Libby Dam, presents an impassable fish barrier. As the river flows through the northeast corner of Idaho, a definite reach change occurs at Bonners Ferry. Upstream from town, the river has an average gradient of 0.6 m/km, with velocities higher than 0.8 m/s. Downstream from Bonners Ferry the river slows, deepens, and meanders through the Kootenai Valley back into B.C., into the south arm of Kootenay Lake. The river leaves the lake through the west arm to a confluence with the Columbia River at Castlegar. A natural barrier at Bonnington Falls, and now Corra Linn Dam, have isolated the Kootenai white sturgeon Acipenser transmontanus from other populations in the Columbia River basin for approximately 10,000 years (Northcote 1973). The basin drains an area of 49,987 $km^2$ (Bonde and Bush 1975).

## Development

Spring floods were common prior to commencement of operation of Libby Dam in 1972. Constructed by the D.S. Army Corps of Engineers, Libby Dam provides flood control and hydropower generation and is part of the Bonneville Power Administration (BPA) network. Dam operation drastically alters natural flow levels by storing water during spring runoff and discharging power peaking flows during late summer and fall. Corra Linn Dam effectively raises the mean level of Kootenay Lake 2.4 m, influencing the river level to Bonners Ferry.

To protect agricultural land between Bonners Ferry and Kootenay Lake, the riverbanks have been diked extensively since the 1920s, effectively removing most backwater and slough areas from the river system.

## Contaminants

Prior to construction of Libby Dam, most point source pollution in the Kootenai River drainage came from a mine and fertilizer plant upriver on the St. Mary River (Bonde and Bush 1975) . The ASARKO mine (copper and silver) on Lake Creek near Troy, Montana is the only current mining operation in the drainage below the dam. The closed Snowshoe Mine on Snowshoe Creek (tributary to Libby Creek) was reclaimed in 1989 due to water quality problems.

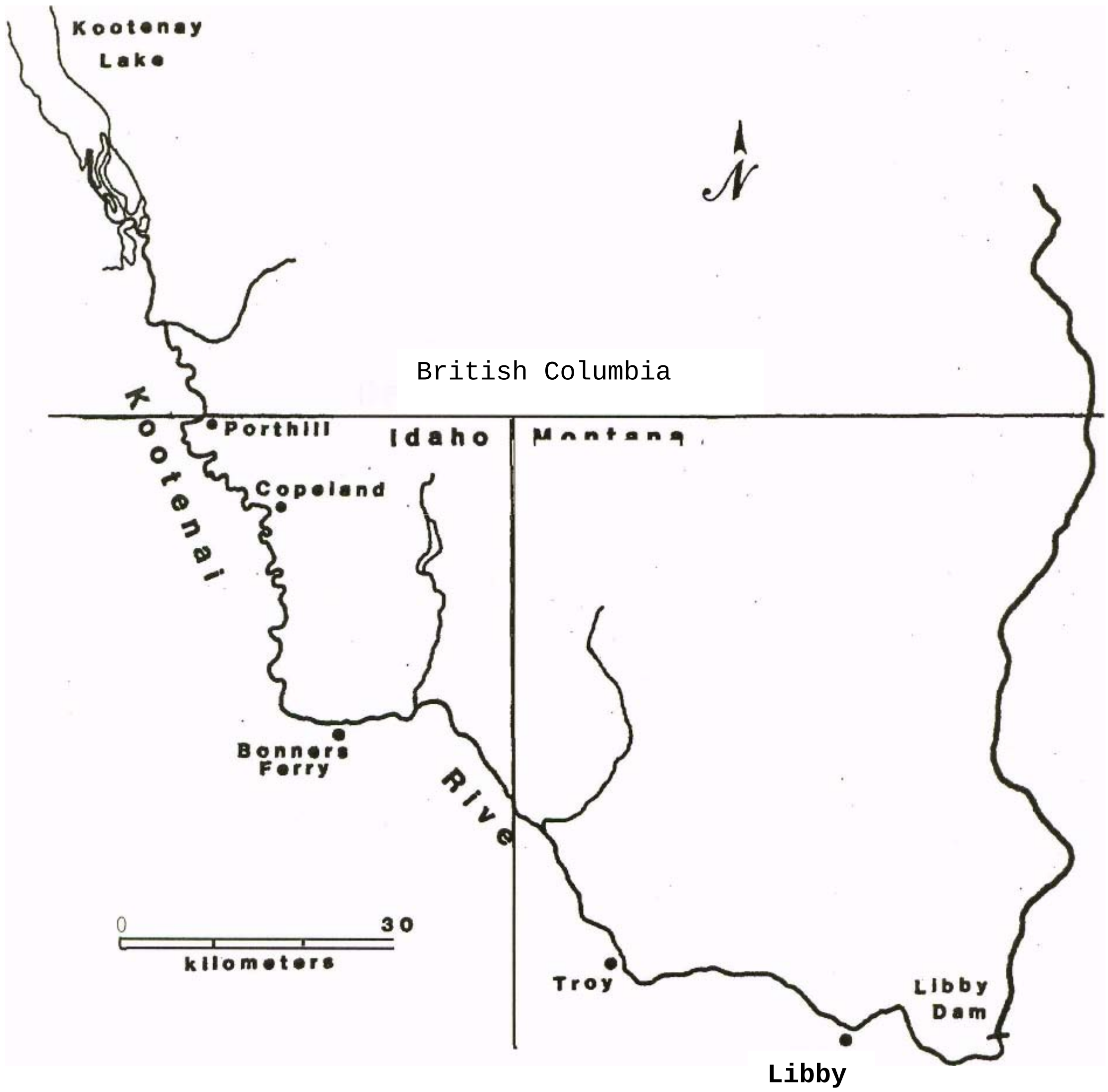


Figure 1. Map of the Kootenai River. White sturgeon are found downstream from Kootenai Falls, and primarily downstream from Bonners Ferry, Idaho

## Sturgeon Fishery

### Idaho

Harvest of white sturgeon from the Kootenai River has been regulated in Idaho since 1944 when commercial fishing was prohibited. Increasingly restrictive statewide harvest limits and length restrictions were imposed over the years (Table 1). From 1944 through the mid-1970s, 10 to 20 fish were harvested per year; an estimated 43 to 50 sturgeon per year were harvested from 1979 through 1982. The first and only prior investigation of fisheries resources on the lower Kootenai River was conducted from 1979 through 1982 by Partridge (1983). Partridge found that only 13% of his sample of sturgeon were younger than age 15 and smaller than 92 cm total length, the legal size for harvest. Concluding that this lack of recruitment of juveniles was limiting the fishery, harvest of sturgeon was terminated in 1984.

### Montana

Prior to 1972, harvest of white sturgeon was not restricted in Montana (Table 1). Harvest was restricted to 2 fish per year (102 to 183 cm TL) for the next six years, then the fishery was completely closed in 1979 (Graham 1981). Five to 18 sturgeon were legally harvested annually during that period. Montana officials have declared white sturgeon a "species of special concern" due to the very small number (an estimated 5 fish) residing in the river in 1979.

### British Columbia

Sturgeon harvest has been restricted in B.C. since 1952 (Table 1). Since 1974, anglers in B.C. have been allowed to harvest one sturgeon per year with a minimum length restriction of 1 m. Beginning in 1989, setlining for white sturgeon was prohibited, and they may now only be taken by angling. A reported 5 to 18 fish are harvested annually, and illegal harvest may increase that estimate by 50% (Andrusak 1980). Since 1977, the B.C. Ministry of Environment has tagged 180 sturgeon at the mouth of the Kootenai River as it enters the south arm of the lake. Several of those fish have been recaptured in Idaho.

## OBJECTIVES

General knowledge regarding habitat requirements of white sturgeon and our understanding of environmental influence on distribution, movement, spawning behavior and success, and juvenile survival is insufficient to allow us to determine, without further investigation, how man's development of the Kootenai River has impacted this species.

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Table 1. A history of fishing regulations for white sturgeon in the Kootenai River.

| Year | Sturgeon fishing regulations | | |
|---|---|---|---|
| | Idaho | Montana | British Columbia |
| 1944 | 2 in possession; no yearly limit; no commercial harvest | | |
| 1948 | 1 setline; 1 in possession | | |
| 1949 | 1 setline; 1 in possession; 76 cm minimum size | | |
| 1952 | | | setlines permitted; 1 per day; 92 cm minimum size |
| 1955 | 1 setline; 1 in possession; 102 cm minimum size | | |
| 1957 | 1 setline; 2 per year; 1 in possession; 102 cm minimum size | setlines permitted for ling only | |
| 1960 | 1 setline; 2 per year; 1 in possession; 92 - 183 cm length restriction | | |
| 1968 | | setline permitted for sturgeon February 15 through June 30 | |
| 1973 | | 6 setlines with 6 hooks per line permitted February 15 through June 30; 2 per year; 102 – 183 cm length restriction | |
| 1975 | | no setlines permitted; 2 per year; 102 - 183 cm length restriction | |
| 1978 | | | 100 cm minimum size |
| 1979 | 2 per year; 1 in possession; 92 - 183 cm length restriction; permit required | closed | |
| 1981 | | | 1 per year; 100 cm minimum size |
| 1982 | | | Sturgeon declared a game fish |
| 1983 | setlines prohibited; season: July 1 through December 31 ; 1 per year; 92 - 183 cm length restriction | | |
| 1984 | catch and release only; open all year | | |
| 1989 | | | setlines prohibited |

This project, authorized by the Northwest Power Planning Council (1987) and funded by BPA, is an effort to identify environmental factors limiting the white sturgeon population in the Kootenai River and to recommend effective mitigative actions to restore the wild population. Concurrently, BPA is providing the Kootenai Indian Tribe of Idaho with funding to develop an experimental white sturgeon hatchery on the Kootenai River. The Idaho Department of Fish and Game and Kootenai Tribe are working cooperatively to meet the goal of restoring this population. Objectives for 1989 were to:

1. Assess the status of white sturgeon in the Kootenai River between Kootenay Lake and Kootenai Falls with regard to distribution, population size, reproduction, and recruitment.

2. Describe diel, weekly, and seasonal movements of white sturgeon and to describe the frequency of use of physical habitat parameters, including depth, focal point velocity, temperature, and turbidity.

3. Experimentally culture white sturgeon from the Kootenai River to determine gamete viability. (Because of a delay in the construction of the hatchery, no experimental spawning or culture of sturgeon was conducted in 1989).

4. Measure levels of contaminants in sturgeon ova and in river sediments.

5. Assess the genetic status of the Kootenai River sturgeon population.

## RECOMMENDATIONS

1. We recommend that the closure to harvest of white sturgeon in the Kootenai River be continued in Idaho and Montana and expanded to British Columbia until the factors which have eliminated recruitment are overcome. Our data indicate no recruitment since 1977, suggesting this population cannot withstand further harvest without risking an irrecoverable loss of adults needed for recovery.

2. No more than 10,000 age 0 to age I offspring from Kootenai River broodstock should be released into the Kootenai River in 1990-91 to monitor survival of juvenile fish and to begin a recovery program for the population. This should provide protection to existing genetics.

3. Identify habitat availability for white sturgeon at all life stages in the lower Kootenai River. This work could be done in conjunction with ling habitat and flow modeling being done by Montana.

4. Due to total recruitment failure-and genetic differences from other white sturgeon, developing a petition to list the Kootenai River white sturgeon as an endangered species is recommended.

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# METHODS

## Population Status

### Capture of White Sturgeon

**Setline Sampling-**Setline sampling was the primary technique used to capture white sturgeon. Each setline consisted of a 27 m mainline of 0.64 cm diameter twisted, medium lay nylon line, with a gangen line attached every 3 m for a total of six per setline. Gangen lines consisted of a stainless steel mainline snap with a 4/0 ball bearing swivel attached, with a large stainless steel hog ring, 100 to 250 kg test gangen twine, and a cadmium-tin coated circle tuna hook, size 16/0, 14/0, or 12/0. Each gangen line measured 45 cm long from mainline to hook. Each setline was rigged with two gangen lines of each size hook, placed in random order on the mainline. One 10-kg weight was tied to each end of the setline, as were float lines and buoys. Hooks were baited with chunks of adult kokanee salmon Oncorhynchus nerka with little exception (nightcrawlers, squawfish Ptychocheilus oregonensis, and peamouth Mylocheilus caurinus were used occasionally during the beginning of the sampling season). For the first six weeks of sampling, half of the lines set were rigged with J-shank 6/0 hooks in place of circle hooks to determine relative catch rates of the different style hooks. Beginning in August, additional setlines were rigged with ten 10/0 circle hooks spaced 1.5 m apart in an effort to sample sturgeon too small to be recruited to the larger gear. These lines were set in slough and backwater areas as well as in the main river.

**Rod and Reel Sampling**-Setline sampling was supplemented with rod and reel sampling as time permitted. Six- to seven-foot long rods with bait casting reels were rigged with 36-kg test dacron line, approximately 0.3 kg of weight, and assorted hook styles and sizes.

**Electrofishinq**-The lower 0.5 km of the East Channel of the Kootenai River and the bay between the mouth of the East Channel and the main river channel was electrofished at night on August 10.

### Treatment of Captured Sturgeon

**Handling-**Sturgeon were slid into a 2.2 m x 1m hooded vinyl stretcher in the water then lifted into the boat, supporting the poles of the stretcher across the gunwales. Enough water was bucketed into the stretcher to allow the sturgeon to gill throughout handling time. Sturgeon longer than 220 cm were not brought into the boat, but were examined in the stretcher in a wadable depth of water.

**Measurements and Taqqinq**-All captured sturgeon were measured for fork length (FL) and total length (TL), tagged with a red,, numbered Floy FT-10 (30 cm long spaghetti-type) tag pierced through the flesh just below the anterior end of the dorsal fin, and tied with a loop knot. Beginning June 13, all sturgeon also received a Passive Integrated Transponder (PIT) tag inserted into the dorsal musculature at the base of the right side of the dorsal fin. A subsample of sturgeon was weighed to the nearest kg on a 100 kg capacity hanging scale by winching the stretcher with a hoist. Beginning August 10, all sampled sturgeon received 100 mg/ml oxytetracycline (OTC) at approximately 25 mg OTC/kg body weight. The antibiotic was injected 5 ml at a time into the anterior part of the dorsal musculature. In addition to serving as an antibiotic to prevent possible infection from surgery and handling stress, the OTC should provide a reference mark on pectoral fin-ray samples to be collected in the future. We estimated the age of all sturgeon that had been aged during the past study and could be identified by old tags. We aged additional fish representative of length groups. To collect samples for aging sturgeon, a 5 mm section of the leading pectoral fin-ray was removed 5 mm from fin articulation. A hacksaw was used to cut through the ray and a fillet knife used to separate the first ray from the fin.

**Sex Determination**-Most sturgeon longer than 120 cm TL were sexed by surgical incision following methods outlined in Conte et al. (1988). A 1.5 cm incision was made, with a size 10 or 15 surgical blade, on the ventral side at the fourth ventral scute anterior to the anal opening and halfway between the scute line and ventral line. A veterinary otoscope, with a 7 mm or 9 mm speculum, was inserted into the incision to aid in determining sex and stage of maturity of fish. Females were classified as nonvitellogenic (ovaries undifferentiated with no oocytes visible), early vitellogenic (oocytes present, white to yellow in color and <2.5 mm in diameter), or late vitellogenic (many oocytes, grayish and >2.5 mm in diameter). A bactericide (4% nitrofurazone solution) was liberally applied to all surgical instruments, to the area around the incision, and to the inside of the body cavity. A 0.64 cm tygon tube was used to pipet a 15 g ova sample from females with oocytes larger than 2.5 mm. These samples were frozen for contaminants analyses. Incisions were sutured using 4.0 metric chromic gut swatched to a CP-2 cutting needle. The incision area was wiped dry and a tissue adhesive applied to seal the wound.

**Collection of Muscle Tissue Samples**-A sample of muscle tissue was collected from each of 56 white sturgeon for electrophoretic analysis. A small incision was made through the skin at mid body, just below the layer of fat along the dorsal ridge, and a cork borer used to extract the 3 x 5 mm sample. The wound was flushed with nitrofurazone and then sutured closed.

## White Sturgeon Movement and Habitat Use

In our original sampling design, we intended to track movements of adult white sturgeon caught in four sections of the river; four fish in Montana,

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fish in Idaho between Bonners -Ferry and Copeland, six fish in Idaho between Copeland and Porthill, and four fish in B.C. between Porthill and Kootenay Lake. We hoped to track movements of an equal number of males and females. These sites were chosen to allow sampling over a large area of the river, while concentrating on data collection from areas criticalto investigation of sturgeon. The Montana site was chosen to locate and define movements of sturgeon where they are nearly extinct. The Idaho sites represent areas where past catch rates and densities were relatively high (Partridge 1983). The B.C. site was chosen to examine whether sturgeon migrate to and from the lake, and at what times of the year these migrations may be occurring.

Ultrasonic transmitters used (manufactured by Sonotronics of Tuscon, Arizona) operate at a frequency of 74 Khz and emit a three or four digit pulsed code for identification. The transmitters were of three types: ten with 12-month batteries (Model CT-82-1); five with temperature monitors, also with 12-month batteries (Model CTT-83); and five with 2-year batteries (Model CHP-87). Transmitter models CT-82-1 and CTT-83 are 16 mm in diameter, 60 mm long, weigh 20 g in air and 8 g in water, and have a maximum range of 1 km in unobstructed waters. Transmitter model CHP-87 is 18 mm in diameter, 100 mm long, weighs 32 g in air and 13 g in water, and has a maximum range of 3 km. All transmitters are contained in a polyvinyl chloride (PVC) shell-with a small hole at each end for external attachment.

Transmitters were mounted externally because that was quicker and easier than surgical implantation and allowed the potential to eventually remove or replace transmitters. Transmitters were attached by passing a single braided stainless steel wire through the holes in the transmitter, then through a 15.2 cm 16-gauge hypodermic needle, which was inserted through the flesh just below the anterior and posterior edges of the dorsal fin. The wire was then fed through holes in a piece of PVC tubing of equal dimensions as the transmitter on the other side of the fish (Figure 2). After the wire was passed through holes in both walls of the tubing, it was cut and crimped with metal leader sleeves to secure the transmitter snugly to the side of the fish. The tubing helped distribute weight evenly on the fish and ensured that the attachment wires did not pull through the flesh. A directional hydrophone (Sonotronics Model UR 5 B or Smith-Root Model TA-25) was used to locate fish carrying transmitters. Locations of each fish, to the nearest 0.1 river km, were determined weekly during summer 1989 and monthly to biweekly through November. To assess diel sturgeon movement during summer, locations of six randomly chosen fish were documented at hourly intervals over a 24-hour period.

Focal point current velocity, water depth, temperature, and turbidity were measured at the same time and location that fish were found. A Price AA current velocity meter and a YSI Model 33 temperature meter were used to measure current and temperature, respectively. Water depth was recorded with a Lowrance X-16 echosounding chart recorder, and a Kemmerer bottle was used to collect water samples for turbidity measurements. Turbidity was measured with a Hach Model DREL-5 portable spectrophotometer and expressed in Formazin Turbidity Units (FTUs).

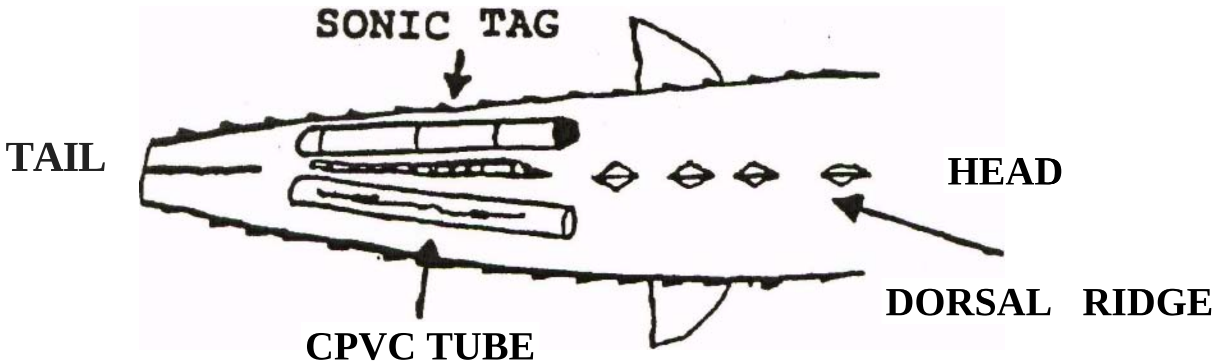



Figure 2. External attachment of an ultrasonic transmitter on a white sturgeon

Use curves for measured habitat parameters will be generated with the Macintosh Statview computer program (Abacus Concepts, Inc. 1986). To assess the influence of various flow regimes on sturgeon movements, including power peaking at Libby Dam, and to test for the presence of a threshold current velocity for sturgeon movement, flow data will be correlated with fish location and movement data using correlation functions. Continuous river flow data from gauging stations will be provided by the U.S. Geological Survey (USGS). Results from these analyses will be presented in the 1990 annual report.

## Population Estimate

Sturgeon sampling was conducted from mid-March through October, 1989. Four sampling passes were made between Kootenai Falls and Kootenay Lake (Figure 1). Each pass took eight weeks to complete, and all sections of the river that were possible to fish were sampled. Any sturgeon caught and tagged superfluous to this sampling regiment were omitted from the population estimate. A modified Schnabel multiple mark recapture method was used to estimate the size of the sturgeon population (Ricker 1975). The following formulas were used:

$$\hat{N} = \frac{(C_t M_t)}{R_t + 1}$$

Ninety-five percent confidence intervals were computed using a Poisson distribution:

$$1-P = R_t + 1.92 \pm 1.96 \sqrt{R_t + 1}$$

where:

$C_t$=total sample taken during pass t,

$M_t$=total marked fish at the start of the $t^{th}$ pass,

$R_t$=number of recaptures in the sample $C_t$.

## Aging

To determine fish age, a 2 mm thick section was cut from each dried pectoral fin-ray sample using a jewelers saw and vise. Both sides of the sample were polished with 600 grit sandpaper and permanently mounted on a microscope slide with clear fingernail polish. Annuli were counted with aid of a compound microscope using transmitted light set at 40X magnification.

## Analysis of Contaminants

Levels of copper, zinc, and organochlorides in white sturgeon oocyte samples and in Kootenai River sediment samples were determined by Am Test, Inc. of Redmond, Washington. Metals were analyzed in accordance with Environmental Protection Agency (EPA) method 6010 (US EPA 1986) and organochlorides were analyzed according to Method PPB 12/83 (US EPA 1983. Copper and zinc were chosen because previous water quality monitoring singled out these two metals as being at potentially harmful levels (Bonde and Bush 1975). Organochlorides were measured because relatively high levels of DOT and its metabolites and polychlorinated biphenyl (PCB) were found in a sturgeon ova sample in 1982.

## Genetic Analysis

Complete methods used for electrophoretic analysis of muscle tissue samples are presented in Appendix A.

# RESULTS

## Population Structure

### Population Estimate and Abundance

A total of 228 white sturgeon were captured and marked with Floy tags in 1989. The latter 159 of those fish also received PIT tags. Twenty-one fish were recaptured (with 23 incidences of recaptures). Six Floy tags were lost from recaptured fish during the year. All PIT tags were secure in recaptured fish. With one exception, all sturgeon were captured between river km (x-km) 244.5 (1 km downstream from the Highway 95 bridge at Bonners Ferry) and the Kootenay Lake delta at rkm 120. One sturgeon (105 cm FL) was caught in Montana at rkm 310.5, 2 km below Kootenai Falls. Fork length of white sturgeon in the sample ranged from 94 cm to 274 cm, with a mean of 147 cm (Figure 3). Total lengths ranged from 109 cm to 308 cm, with a mean of 166 cm.

The population size was estimated at 850 individuals, with 95% confidence intervals of 574 to 1,463. This translates to' an average abundance of seven sturgeon per km between Bonners Ferry and Kootenay Lake.

We expended a total effort of 15,075 hours of setline effort (setlines rigged with six hooks each) to capture 220 white sturgeon; 4,548 hours for 53

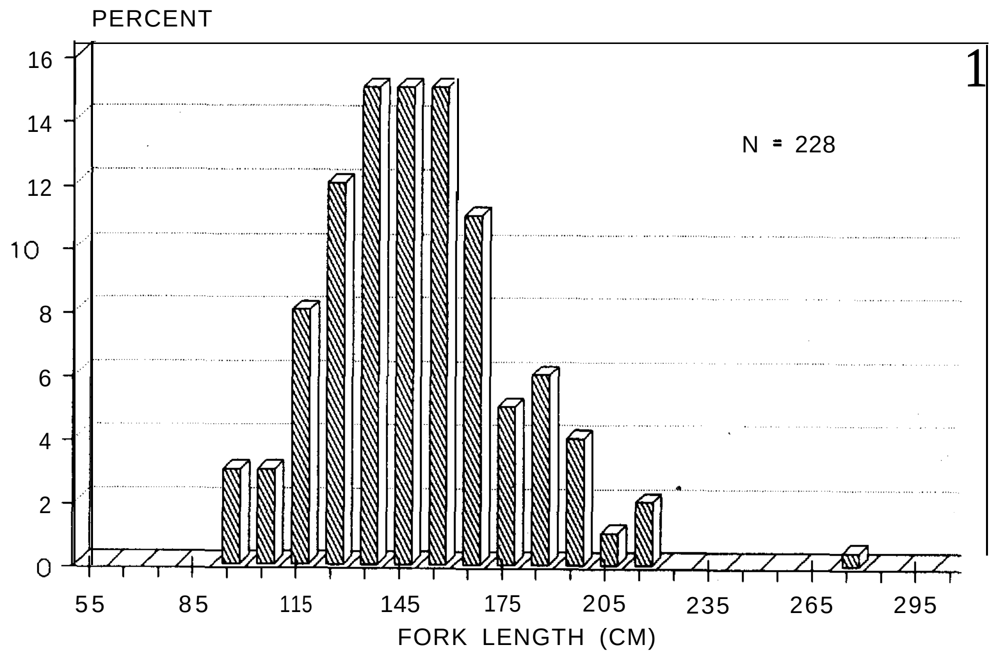



Figure 3. Length frequency of white sturgeon sampled from the Kootenai River, 1989.

fish in B.C., 8,095 hours for 173 fish in Idaho downstream from Bonners Ferry, 690 hours for 0 fish in Idaho upstream from Bonners Ferry, and 1,487 hours for two fish in Montana (Figure 4). Overall catch rate in Idaho was double that in B.C. Small setlines (rigged with ten 10/0 or smaller hooks) were fished for a total of 1,220 hours, but caught only 2 sturgeon. Weekly catch per setline hour was highest during July at relatively low discharge and high temperatures (Figure 5). Drastic fluctuations in discharge that began in August often fouled our overnight sets, and catch per unit effort declined throughout the fall.

Project angling effort was sporadic. Holes with historically higher densities of sturgeon were usually selected for angling effort. Angling effort totalled 716.4 rod hours to catch 24 fish.

## Gear Selectivity

The smallest white sturgeon captured recruited equally to all three sizes of circle hooks. The 12/0 hooks did appear to select for sturgeon smaller than 170 cm FL. Except for the disproportionate number of 160 cm sturgeon caught by 16/0 hooks, no differential selection was apparent between the 14/0 and 16/0 hook sizes (Figure 6). We discontinued using J-type hooks after having several fish straighten hooks and escape. The J-type hooks were occasionally swallowed by sturgeon, whereas circle hooks always caught fish in the mouth, making release less stressful.

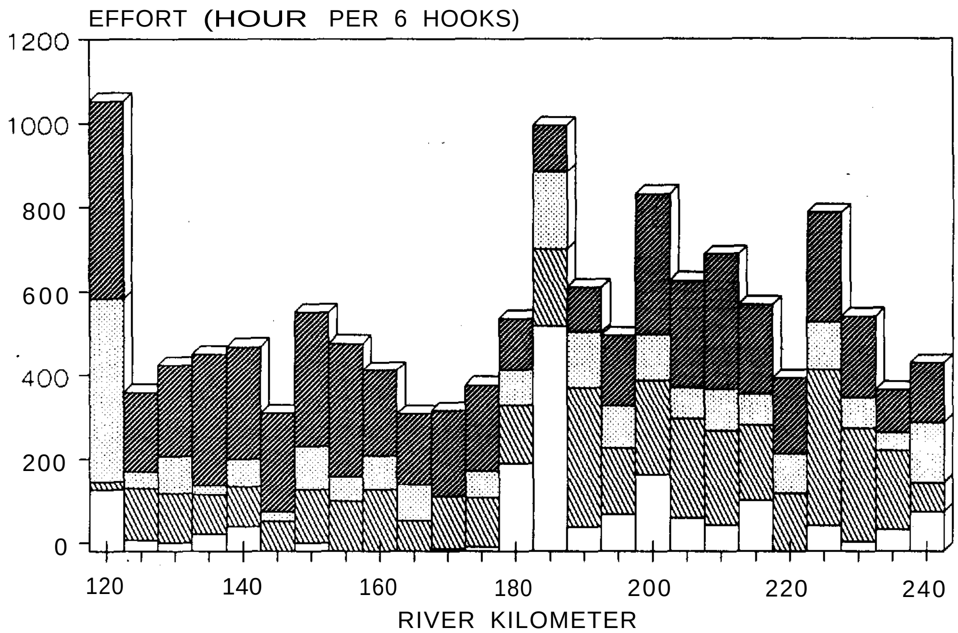
Electrofishing efforts produced no sturgeon.

## Maturity

A total of 179 white sturgeon were surgically examined to determine sex and stage of maturity. We identified 63 males and 66 females. We were unable to determine the sex of the remaining 50 fish due to uncertainty in identification of gonadal tissues. Lengths of females ranged from 110 to 219 cm FL; males ranged from 115 to 186 cm FL. Thirteen percent of the females sampled were vitellogenic (Figure 7) and may be developed enough to spawn in 1990. Therefore, we could assume that there may be as many as 55 females in the population that may spawn in a given year. No ripe males were encountered. We defined ripe males as those with extractable milt when pressure was applied to testes.

## Genetics

Electrophoresis results for the 56 muscle samples collected in 1989 and nine samples collected in 1987 from the Kootenai River delta (rkm 120} are reported here in combination. Allele frequencies were determined for 28 enzyme systems. Average heterozygosity, a measure of the quantity of variation, was



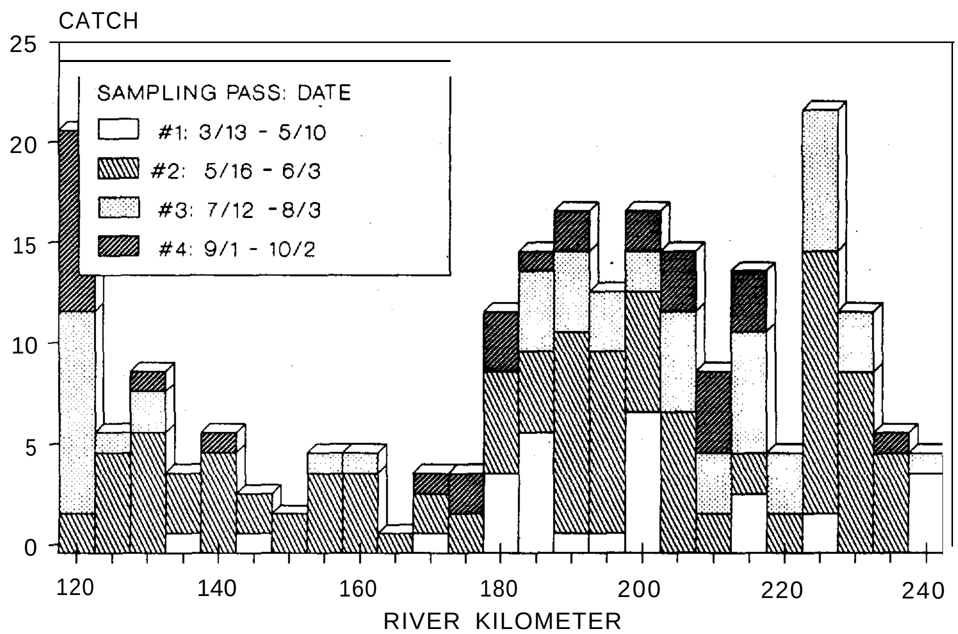




Figure 4. Effort expended and catch of white sturgeon by river kilometer from Bonners Ferry, Idaho to Kootenay Lake, B.C., 1989.

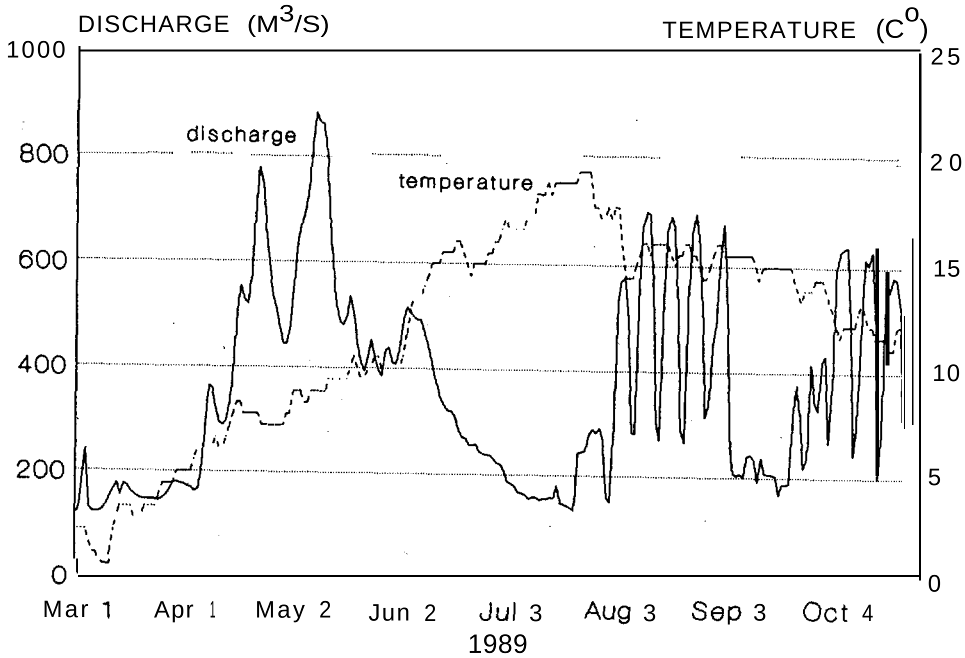



Figure 5. Kootenai River mean daily discharge and minimum daily temperature at Porthill, Idaho, 1989.

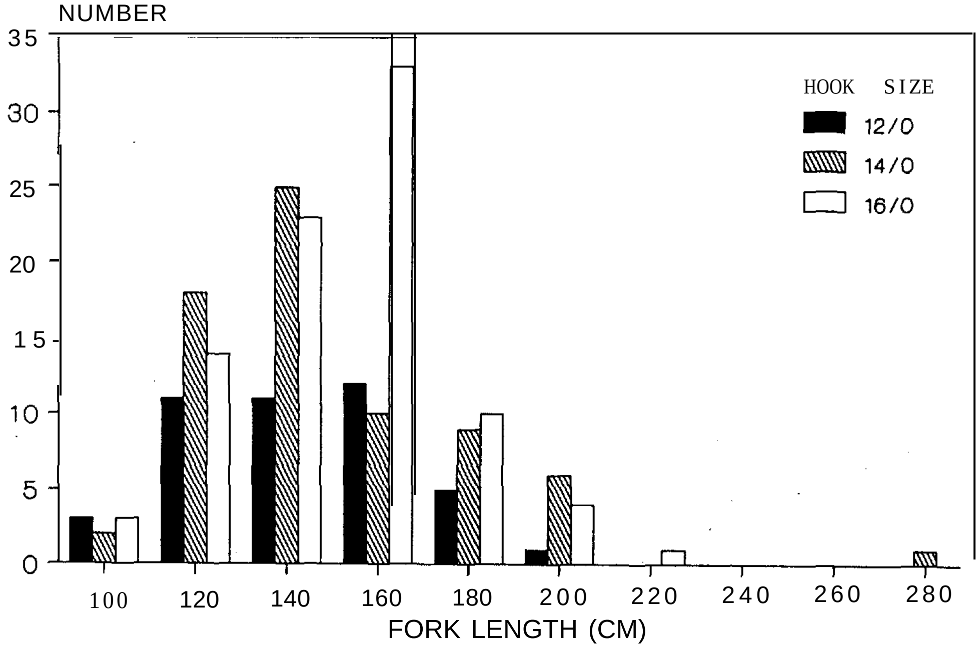



Figure 6. Selectivity of hook sizes by white sturgeon in the Kootenai River, 1989.

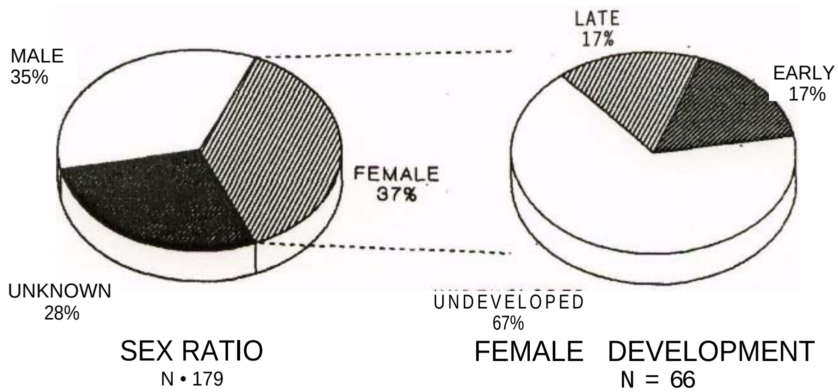



Figure 7. White sturgeon sex ratio and female development, Kootenai River, 1989.

0.054 (Appendix A). We feel this sample adequately represents the Kootenai River population.

## Contaminants Analysis

All nine samples of white sturgeon oocytes contained zinc and copper. Levels of copper ranged from 1.18 to 2.50 µg/g dry weight (Table 2). Zinc was found at concentrations of 18.8 to 32.8 µg/g dry weight.

Organochlorides found in oocytes included DOT, ODD, DDE, and PCS (as Aroclor 1260); levels found ranged from 0.215 to 1.080 µg/g wet weight. Because extracts from three samples were inadvertently combined by Am Test, organochloride levels were measured in only six oocyte samples.

River sediment samples contained 1.62 to 12.8 µg/g copper and 22.4 to 70.6 µg/g zinc. Metal concentrations were considerably higher at the downriver site. No organochlorides were found in river sediments.

## Movement and Habitat Use

Sampling efforts in Montana failed to capture any reproductively mature sturgeon for transmitter attachment. As a result, 16 fish in the Idaho sections of the river and four fish in B.C. received transmitters (Figure 8).

### Weekly and Seasonal Movement (Telemetry)

Sturgeon movement data presented were gathered from June 30 through November 15, 1989. Prior to statistical analysis, much sturgeon movement appears to be random with some exceptions, including sustained upstream and downstream movements of more than 20 km by four fish that were apparently triggered by the first major summer water release from Libby Dam on August 1 (increasing discharge from 230 to 790 m/s). Three fish exhibited sustained upstream movements between 30 and 60 km within several weeks of this initial flow increase (Figure 9, #384 and #2228; Figure 10, #456), and one fish exhibited a sustained downstream movement of over 50 km (Figure 9, #2246). Prior to increased discharge three females moved 50 to 60 km downstream (Figure 9, #2255, #2228, and #339), perhaps responding to declining flows during June and July (Figure 5).

From late August through November, sturgeon movements decreased in the middle section of the river (Copeland at rkm 200 to Bonners Ferry at rkm 246). Five fish congregated in deep holes at Rock Creek (rkm 215) and Flemming Creek (rkm 225). Between late August and November, three fish that inhabited the river during summer migrated as far as 95 km into Kootenay Lake (Figure 9, #2228 and #2246; Figure 10, #285) where they remained relatively stationary at depths of 24 to 55 m. In the section of river between Bonners Ferry and Kootenay Lake,

Table 2. Contaminant levels in white sturgeon oocyte and Kootenai River sediment samples, 1989.

| Sample | | Metals ug/g dry wt | | Organochlorides ug/g wet wt | | | |
|---|---|---|---|---|---|---|---|
| Location (rkm) | Date | Copper | Zinc | ODD | DDE | DDT | PCB (a-1260) |
| 140.0[1] | 06/28 | 1.72 | 32.8 | ND[3] | 100[4] | ND | 73[4] |
| 229.7[1] | 07/13 | 1.85 | 22.3 | ND | 100[4] | ND | 73[4] |
| 226.0[1] | 07/14 | 2.24 | 23.1 | ND | 100[4] | ND | 73[4] |
| 225.1[1] | 07/14 | 1.62 | 21.5 | 650 | ND | 130 | 300 |
| 205.0[1] | 07/20 | 1.87 | 23.3 | 440 | 44 | 96 | 330 |
| 198.8[1] | 07/21 | 2.50 | 18.8 | 176 | 6 | 33 | ND |
| 213.2[1] | 07/20 | 1.18 | 20.4 | 360 | 40 | 86 | 200 |
| 122.8[1] | 10/04 | 1.31 | 21.6 | 190 | 28 | 73 | 310 |
| unk | unk | 1.32 | 15.6 | 570 | 61 | 90 | 230 |
| 239.0[2] | 10/03 | 2.85 | 22.4 | ND | ND | ND | ND |
| 215.0[2] | 10/03 | 4.82 | 47.4 | ND | ND | ND | ND |
| 179.0[2] | 10/03 | 2.93 | 41.4 | ND | ND | ND | ND |
| 165.0[2] | 10/03 | 1.62 | 51.7 | ND | ND | ND | ND |
| 126.0[2] | 10/03 | 12.80 | 70.6 | ND | ND | ND | ND |

[1]oocyte sample
[2]sediment sample
[3]ND = no detection
[4]composite of three oocyte samples

TABLES

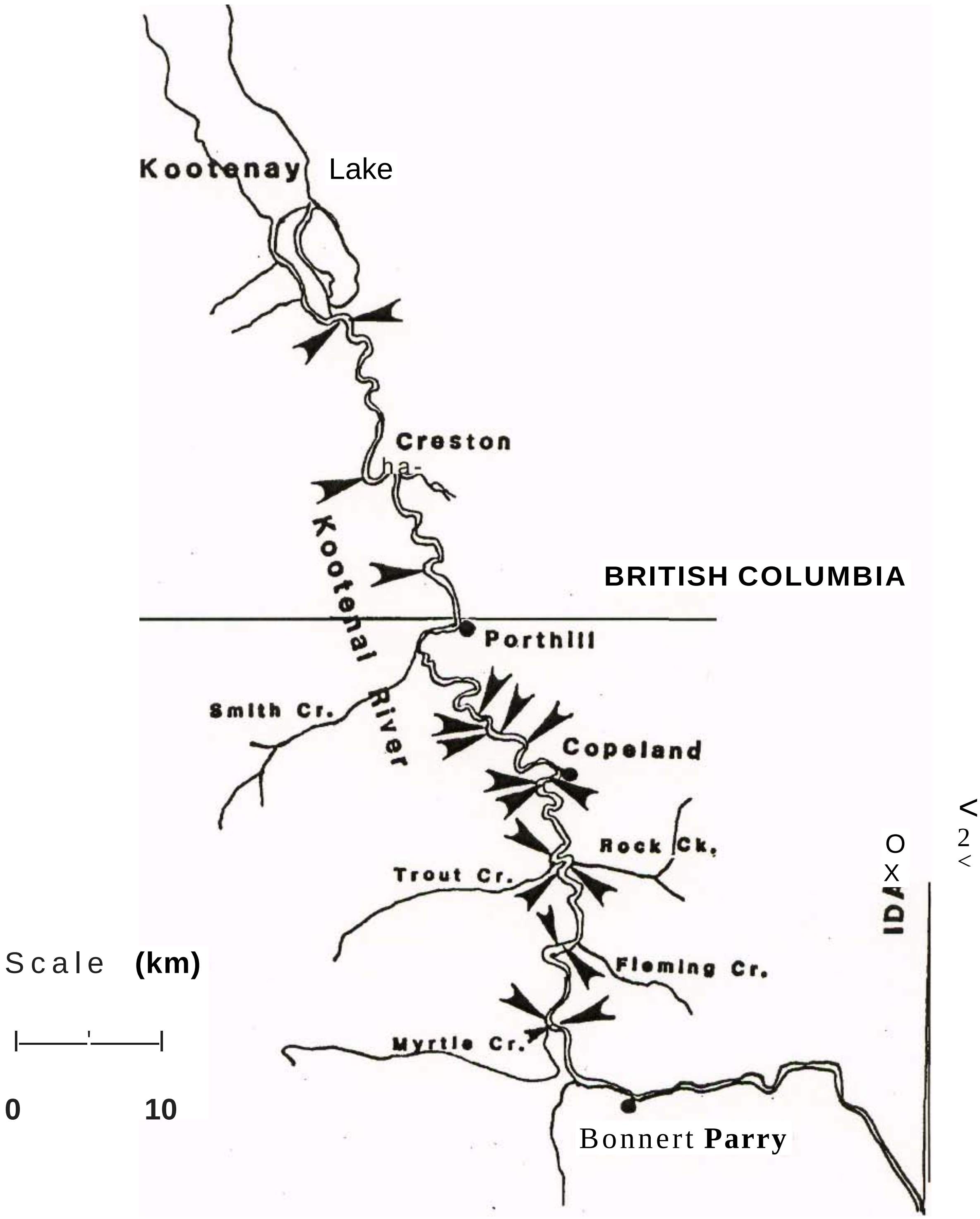



Figure 8. Initial locations of white sturgeon that received sonic transmitters in 1989.

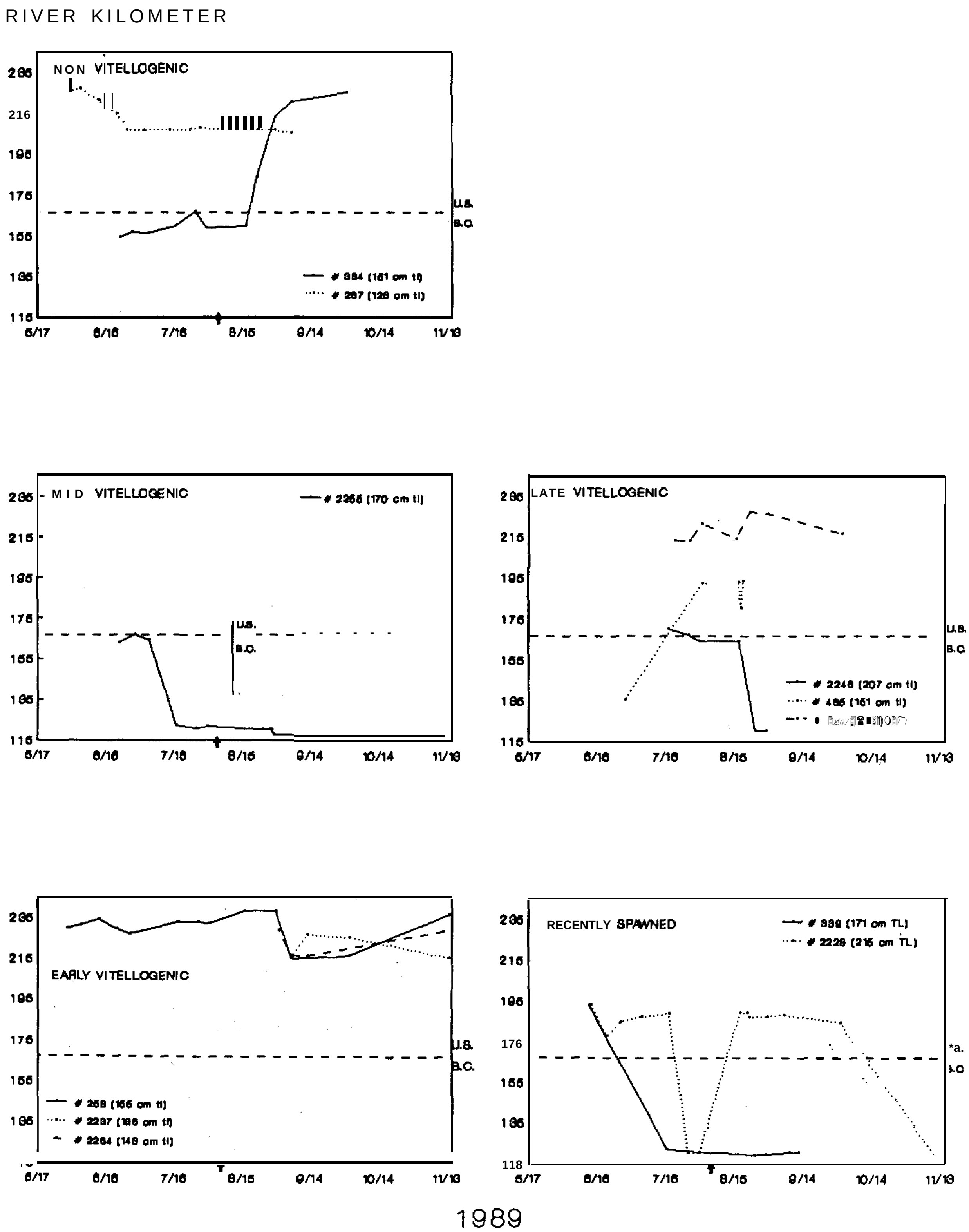
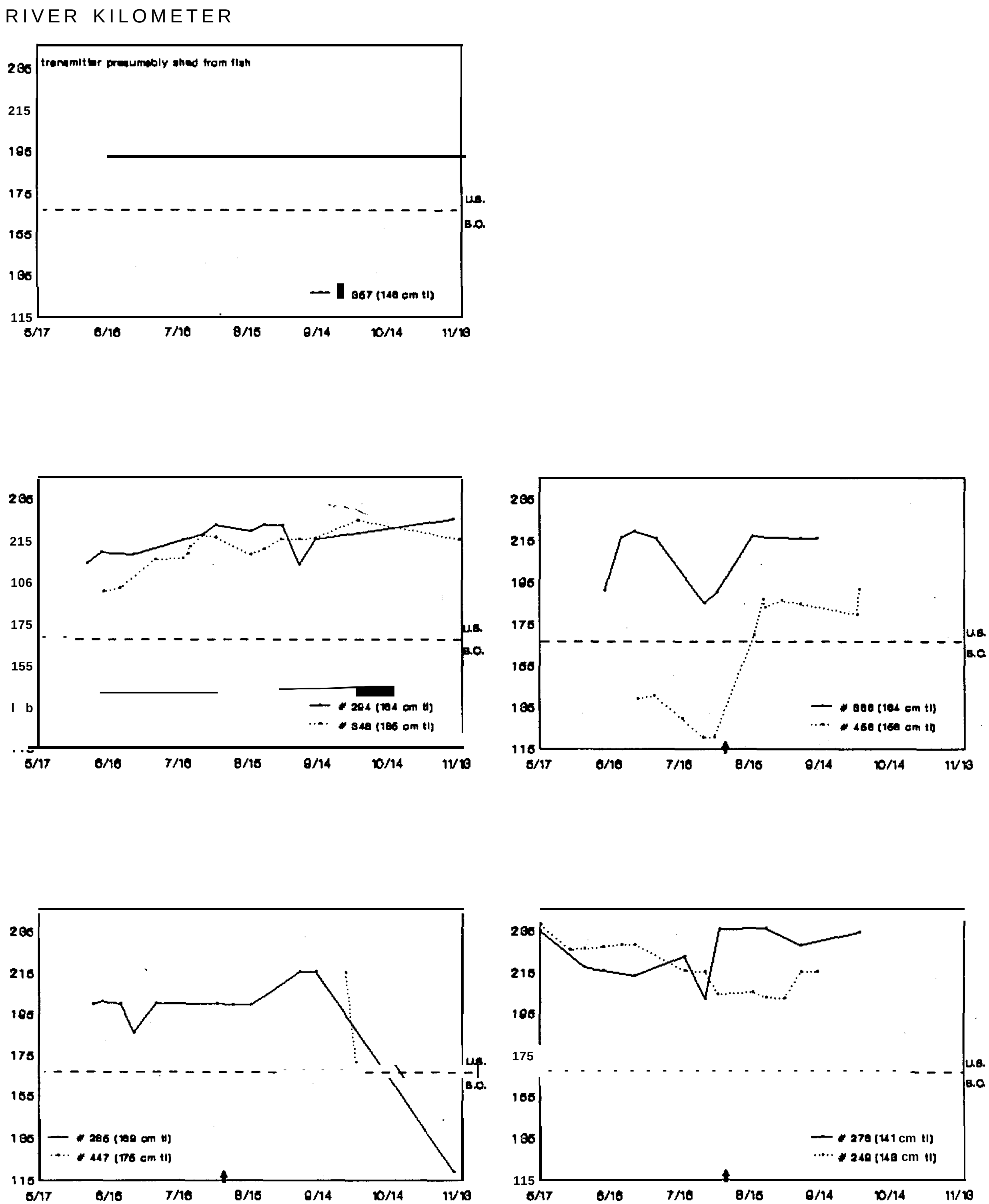



Figure 9. Movements of female white sturgeon in the Kootenai River, 1989; arrows on x-axes indicate time of increased discharge from Libby Dam.




1989

Figure 10. Movements of male white sturgeon in the Kootenai River, 1989; arrows on x-axes indicate time of increased discharge from Libby Dam.

we were able to locate 14 to 17 of the 20 fish weekly through Septembers but only 6 to 10 fish were located during November and 5 fish were found in December. Movement data and the increased absence of sturgeon in the river from September through November suggests downstream migration of some sturgeon into Kootenay Lake during the fall.

Eight of the 20 fish fitted with transmitters exhibited sustained upstream and downstream movements between 45 to 80 km during 1989 (Figures 9 and 10). Females accounted for six of these cases, while two male fish moved upstream and downstream 70 and 80 km, respectively.

One fish apparently lost a transmitter between June 14 and 21; the transmitter has been in one location since that time. We think the transmitter was shed rather than remaining on a fish that died because this and all other fish released after transmitter attachment appeared in excellent condition, as did recaptured fish with transmitters.

**Point to Point Movement (Recaptures)**

Recaptures of, tagged fish provided some additional information regarding gross movements of sturgeon. Eight fish recaptured more than 10 days following initial capture moved between 19 and 73 km. No pattern with regard to direction, seasonality, sex, or fish size was apparent with these movements (Figure 11). The most dramatic of the movements was a 135 cm FL male that moved 73 km downstream in 10 days in late September-early October. Eight other fish recaptured more than 3 weeks following tagging moved less than 13 km (Figure 11). Similar to those that moved longer distances, we could not group these fish by any similarities, though they were generally found in areas where our catch rates were relatively high.

**Diel Movement**

Six randomly selected fish were located at hourly intervals for a 24-hour period during the summer of 1989. No diel patterns of movement were evident from these data, nor was movement differential with respect to sex. Two of the fish remained in the hole in which they were initially located during the entire 24-hour periods at depths of 15 to 27 m. Both fish exhibited nearly constant movements of less than 0.3 km. Two other fish were located and remained in the Kootenay River delta at Kootenay Lake at depths between 18 and 37 m, with similar movements of less than 0.5 km during the 24-hour periods. The remaining two fish exhibited upstream movements of 6 and 4 km, respectively, the former moving relatively constantly, while the latter remained in a hole at depths of 21 to 27 m for 12 hours, then began the upstream migration at 2400 hours. These 6 and 4 km movements occurred in water depths of less than 12 m.

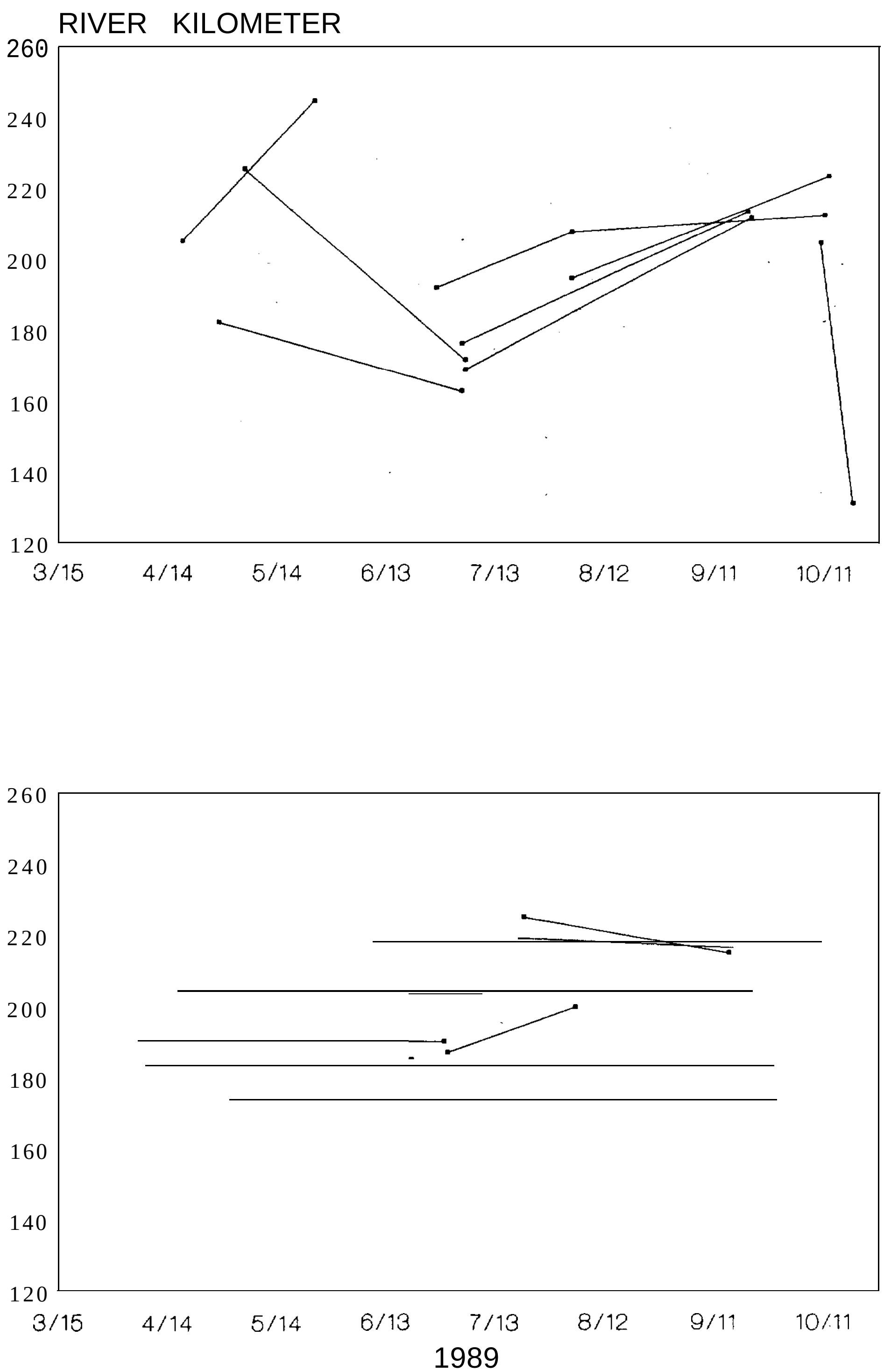



Figure 11. Movements of white sturgeon recaptured >19 km from location of tagging in the Kootenai River, 1989.

## Habitat Use

**Turbidity**-Turbidity measurements where sturgeon were located ranged from 0 to 18 FTUs, with the exception of four readings in November between 84 and 160 FTUs (Figure 12). Turbidity remained below 9 FTU prior to increased water releases from Libby Dam. Following the first major release on August 1, turbidity peaked at 18 FTUs. Slightly lower peaks resulted with subsequent water level manipulations. In the absence of major precipitation, turbidity fell to 0 FTU when the flow remained constant for at least two weeks. Turbidity values of 84 to 160 were recorded in November on the Kootenay River delta and may have resulted from a combination of surface runoff and water level fluctuation. Seven fish exhibited sustained, unidirectional upstream movements of 30 to 90 km after turbidity and flow increased; two fish exhibited similar movements prior to that period.

**Depth**-Sturgeon were located at depths ranging from 4 to 54 m, with a mean depth of 14 m (Figure 12). We located four fish at 52 to 55 m depths in November, which, after inhabiting depths from 18 to 27 m on the river delta, moved into deep water in Kootenay Lake. The use of shallower water (<12 m) by sturgeon appears to be associated with movement, while sedentary fish often remained in holes 12 to 27 m deep.

**Focal Point Velocity**-Current velocities used by sturgeon ranged from less than 0.031 to 0.56 m/s, with a mean value of 0.19 m/s (Figure 12). These values may represent a preferred velocity for sturgeon in the Kootenai River, because velocities of 0.61 to 1.22 m/s were available and apparently not utilized. Major change in river flows (+/- 566 $m^3$/s) from the operation of Libby Dam appear to be an initiating factor for sustained sturgeon movements over 20 km. However, these flow changes did not appear to change sturgeon current velocity utilization freguencies.

**Water Temperature**-Water temperatures where sturgeon were located ranged from 6 to 23°C (Figure 12). Water temperature may affect sturgeon movement in the Kootenai River, however, an insufficient amount of data currently exists to test this hypothesis.

## Age and Growth

Average annual growth rate for 12 white sturgeon tagged in 1979 through 1982 and recaptured in 1989 was 3.1 cm FL and 3.6 cm TL (Table 3). Those fish ranged from 100 to 155 cm FL in 1989. Forty-nine pectoral fin sections were examined from the 1989 sample. Length-at-age is in general agreement between the 1989 sample and the 1979 through 1982 sample, though this sample size was small compared to the number of fish aged during the previous sample period (Table 4). A comparison of six old and new samples of pectoral fin-ray sections

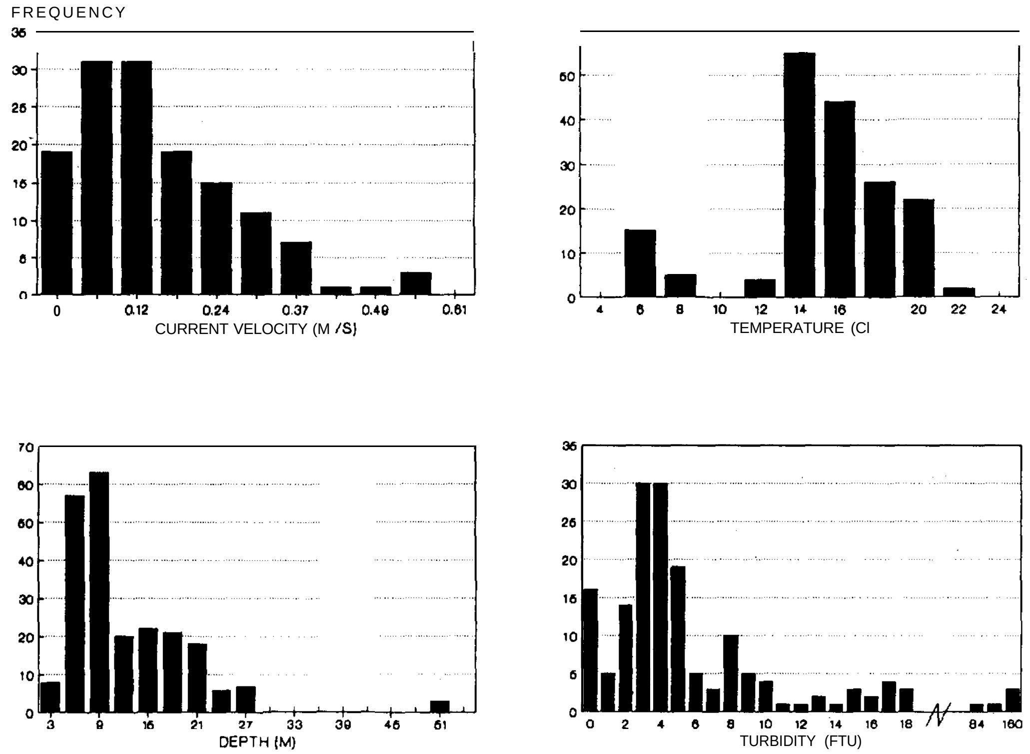



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Figure 12. Turbidity, depth, current velocity, and water temperature utilization frequencies for white sturgeon in the Kootenai River, 1989.

Table 3. Growth rate of white sturgeon in the Kootenai River based on recaptured fish.

| Old tag# | First capture Date | First capture FL(TL) (cm) | Recapture Date | Recapture FL(TL) (cm) | Mean annual growth FL(TL) (cm) |
|---|---|---|---|---|---|
| 03871 | 11/80 | 117(127) | 4/89 | 138(154) | 2.5(3.2) |
| G0648 | 8/81 | 112(125) | 5/89 | 144(158) | 4.1(4.3) |
| 00754 | 7/82 | 127(143) | 5/89 | 135(155) | 1 .2(1 .8) |
| 00652 | 8/81 | 92(102) | 6/89 | 126(143) | 4.3(5.2) |
| 00656 | 9/81 | 92( 99) | 6/89 | 111(123) | 2.4(3.1) |
| 00663 | 9/81 | 129(145) | 6/89 | 155(178) | 3.3(4.2) |
| 00699 | 5/82 | 106(121) | 7/89 | 140(160) | 4.7(5,4) |
| 00748 | 6/82 | 111(127) | 7/89 | 128(143) | 2.4(2.3) |
| 00717 | 6/82 | 69 ( 79) | 8/89 | 100(112) | 4.3(4.6) |
| 00671 | 10/81 | 113(127) | 9/89 | 129(146) | 2.0(2.4) |
| 00728 | 6/82 | 105(119) | 9/89 | 135(153) | 4.1(4.7) |
| 00753 | 7/82 | 118(125) | 9/89 | 135(143) | 2.3(2.5) |
| | | | | | $\bar{x}$ = 3.1 (3.6) |

TABLES

Table 4.Age, mean total length, range of lengths, and length-at-age for sturgeon from the Kootenai River in 1977 through 1982 (Partridge 1983) and in ,1989.

| Aqe | 1977-1982 | | | 1989 | | |
|---|---|---|---|---|---|---|
| | $\bar{x}$ TL (cm) | Ranqe(cm) | (N) | $\bar{x}$ TL(cm) | Ranqe cm) | (N) |
| 4 | 54 | 51-57 | 4 | -- | -- | 0 |
| 5 | -- | -- | 0 | -- | -- | 0 |
| 6 | 64 | 50-73 | 15 | -- | -- | 0 |
| 7 | 70 | 62-81 | 14 | -- | -- | 0 |
| 8 | 77 | 72-83 | 6 | -- | -- | 0 |
| 9 | 79 | 79-80 | 2 | -- | -- | 0 |
| 10 | 82 | 75-87 | 6 | -- | -- | 0 |
| 11 | 86 | 84-88 | 2 | -- | -- | 0 |
| 12 | 96 | -- | 1 | 110 | -- | 1 |
| 13 | 92 | 90-93 | 2 | 106 | 102-110 | 2 |
| 14 | -- | -- | 0 | 110 | 107-112 | 4 |
| 15 | 105 | 99-111 | 2 | -- | -- | 0 |
| 16 | 113 | 103-132 | 4 | -- | -- | 0 |
| 17 | 108 | 95-140 | 17 | 125 | -- | 1 |
| 18 | 113 | 92-138 | 24 | 160 | -- | 1 |
| 19 | 116 | 98-152 | 72 | 139 | 119-158 | 2 |
| 20 | 121 | 93-155 | 52 | 146 | -- | 1 |
| 21 | 133 | 103-169 | 30 | 145 | 123-157 | 3 |
| 22 | 136 | 112-160 | 21 | 147 | 128-165 | 2 |
| 23 | 149 | 109-170 | 11 | 156 | 146-165 | 2 |
| 24 | 157 | 120-173 | 11 | 158 | 130-185 | 8 |
| 25 | 159 | 134-170 | 5 | 165 | 132-194 | 4 |

TABLES

Table 4. Continued.

| | 1977-1982 | | | 1989 | | |
|---|---|---|---|---|---|---|
| Age | x TL (cm) | Range (cm) | (N) | x TL (cm) | Range (cm) | (N) |
| 26 | 158 | 136-171 | 10 | 158 | 130-178 | 7 |
| 27 | 159 | 143-181 | 7 | -- | -- | 0 |
| 28 | 181 | -- | 1 | 137 | -- | 1 |
| 29 | 176 | 169-180 | 3 | 151 | 144-158 | 2 |
| 30 | 192 | -- | 1 | 181 | 167-200 | 3 |
| 31 | 173 | 167-178 | 2 | 234 | -- | 1 |
| 32 | 186 | 185-188 | 2 | -- | -- | 0 |
| 33 | 170 | 149-186 | 3 | -- | -- | 0 |
| 34 | 201 | 183-219 | 3 | -- | -- | 0 |
| 35 | -- | -- | 0 | -- | -- | 0 |
| 36 | 190 | 165-205 | 3 | -- | -- | 0 |
| 37 | 224 | -- | 1 | -- | -- | 0 |
| 38 | -- | -- | 0 | 219 | -- | 1 |
| 39 | 186 | -- | 1 | 230 | -- | 1 |
| 40 | -- | -- | 0 | -- | -- | 0 |
| 41 | 210 | -- | 1 | -- | -- | 0 |
| 42 | 200 | 183-223 | 3 | -- | -- | 0 |
| 43 | -- | -- | 0 | -- | -- | 0 |
| 44 | 203 | -- | 1 | -- | -- | 0 |
| 45 | -- | -- | 0 | -- | -- | 0 |
| 46 | | | 0 | 253 | | 1 |

showed discrepancies between estimated age differences and actual time between collection of samples of up to 3 years (Table 5). Annuli discrepancies occurred on the outer edges of fin-ray sections.

## DISCUSSION

### Population Structure

Except for a 40 cm shift toward larger fish, the pattern of the past and present length frequencies of sturgeon in the Kootenai River are very similar (Figure **13).** Lengths of 417 white sturgeon sampled from the Kootenai River in 1980 through 1982 ranged from 50 cm TL to 224 cm TL, with a mean TL of 122 cm (Partridge 1983). It appears from this and from growth rate data that the same individuals sampled 10 years ago have grown, with virtually no recruitment of juveniles into the population. We do not believe that our sampling gear selected for larger fish. Recruitment of white sturgeon to setline gear has been evaluated by the Oregon Department of Fish and Wildlife in the lower Columbia River (Nigro 1989). Gear identical to ours fully recruited white sturgeon **>90** cm FL and did catch fish as small as 50 cm with all hook sizes. Though we did not capture white sturgeon smaller than 94 cm FL, we did hook many squawfish, especially on **10/0** and 12/0 circle hooks.

A comparison of Partridge's (1983) population estimate (1,194 sturgeon with 951 confidence intervals of 907 to 1,503) with this year's estimate would indicate an overall annual mortality rate of 0.03 for adult sturgeon. We do acknowledge that past and present estimates are not directly comparable because Partridge did not sample in British Columbia, and we found substantial movement of sturgeon between Canadian and U.S. sections of the river. Also, unknown rates of sturgeon movement to and from Kootenay Lake may have biased our 1989 population estimate.

The average abundance of seven sturgeon/rkm in the Kootenai River is comparable to the eight sturgeon/r-km of similar-sized fish found in the middle Snake River (Cochnauer 1983). However, in addition to adults, juveniles (60 to 91.5 cm TL) were found in-the middle Snake River at an average abundance of 18 sturgeon/r-km. Similarly, in Hells Canyon of the Snake River, five sturgeon/rkm were found that were >91.5 cm TL and 20 sturgeon/rkm were found that were 46 to 91.5 cm TL (Lukens 1984).

Our electrophoresis results indicate that the Kootenai River population is genetically distinct from lower Columbia River populations. Of 24 enzyme systems compared between populations, only nine systems from the Kootenai fish were polymorphic versus 17 polymorphic systems found in lower basin fish. In addition, seven systems showed a significantly different .degree of variation ($X^2_{0.05.1}$=3.841 ) between populations (Appendix A). The sex ratio and reproductive potential detected in the Kootenai population are comparable to other populations of white sturgeon. Dr. Serge Doroshov (University of California at Davis, personal communication) noted that consistently 10% of most white sturgeon

Table 5. Comparison of past and present estimated ages of individual sturgeon in the Kootenai River.

| Tag | Past | | Present | | Estimated age | Actual time |
|---|---|---|---|---|---|---|
| Number | Date | Age | Date | Age | difference (y) | lapsed(y) |
| 01085 | 8/13/81 | 15 | 6/08/89 | 24 | 9 | 7.8 |
| 01093 | 9/22/81 | 15 | 6/13/89 | 21 | 6 | 7.8 |
| 01114 | 7/16/80 | 16 | 6/21/89 | 24 | 8 | 8.9 |
| 01215 | 10/21/81 | 18 | 9/13/89 | 23 | 5 | 7.9 |
| 01027 | 8/11/81 | 19 | 5/16/89 | 26 | 7 | 7.8 |
| 01023 | 11/21/80 | 20 | 4/11/89 | 26 | 6 | 8.6 |

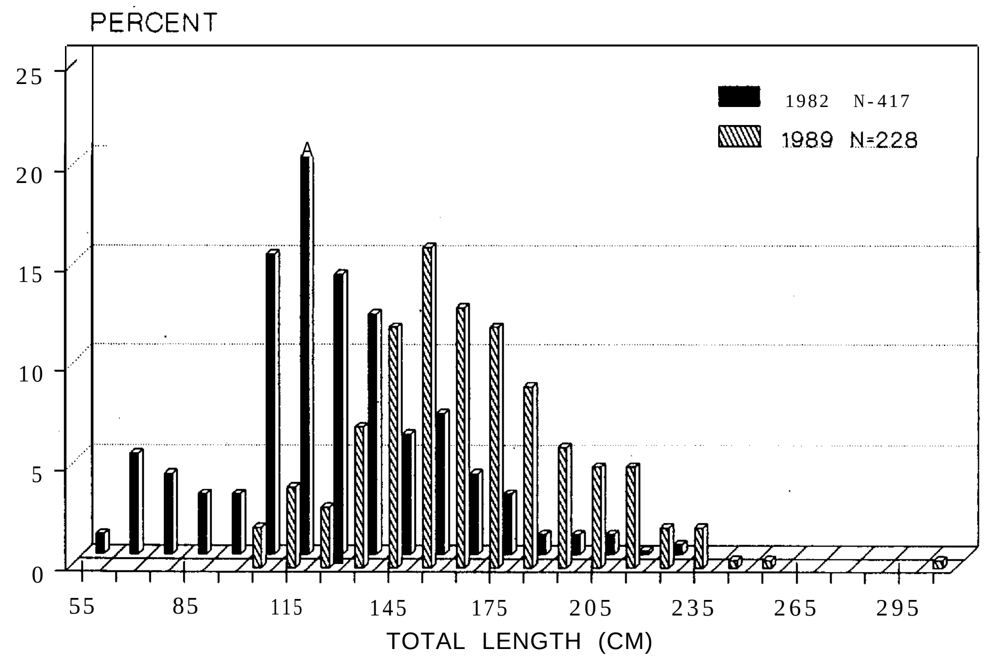


Figure 13. Comparison of past (Partridge 1983) and present lengths of white sturgeon in the Kootenai River.

populations are reproductive at any given time, which holds true for our findings with the female constituent of the Kootenai River population.

Given the above information: a population with the potential for reproduction, but with an inherent reduced genetic variability, we must exercise caution as supplementation efforts are begun. With the facilities to use gametes from a limited number of brood fish, we must limit the number of offspring stocked into the river. Incorporating mortality rates of various age groups from the Snake River populations (Cochnauer 1983; Lukens 1984), we estimate that an annual recruitment of 7,000 subyearling sturgeon would be required to maintain the present adult population.

Extensive aging from fin-ray sections has been recently conducted with white sturgeon from the lower Columbia River (Nigro 1989). Fin-ray sections were read independently by at least two people, and agreement of assigned age was only 35% to 62% for fish 15 to 25 years of age and declining for older fish. However, most discrepancies were only one or two years. As we recapture fish marked with OTC, we hope to validate our aging techniques, if only to develop degrees of confidence for estimating age within given age groups.

## Contaminants

At this point, concentrations of copper found in sturgeon oocytes potentially present the most severe contaminant effect on reproductive success. Water copper levels of only 9 µg/kg appeared to inhibit yolk uptake in larval white sturgeon. (Joel Van Ecnennarin, University of California at Davis, personal communication). Copper levels in the Kootenai River at Porthill range from 2 to 12 µg/kg (1983-1986, USGS records), and concentrations of copper in our oocyte samples were 100 to 250 times higher than those found lethal to larval white sturgeon.

Nothing is known regarding the toxicity of zinc to white sturgeon. Current water quality criteria to protect freshwater aquatic life is 47 µg/kg as a 24-hour average (U.S. Environmental Protection Agency 1984). Concentrations of dissolved zinc in the Kootenai River at Porthill ranged from 9 to 19 µg/kg from 1983 through 1986.

Organochlorides will accumulate in tissues' with high lipid content, therefore, reproductive organs will have higher concentrations than skeletal muscle. The concentration of PCB (as Aroclor 1260) in water resulting in a tissue residue in fathead minnow Pimephales promelas of 0.5 µg/kg was approximately 0.002 µg/kg (Nebeker 1976). More highly chlorinated PCB mixtures are bioaccumulated in lipids of fish than the lower chlorinated compounds (ie., PCB as Aroclor 1260 is more chlorinated than Aroclor 1242). Water concentration of 1.8 µg/kg PCB (Aroclor 1254) caused a 50% reduction in fathead minnow reproduction.

Levels of organochloride residues in Kootenai River white sturgeon oocytes were generally higher than levels found to damage rainbow trout Oncorhvnchus mykiss (Hogan and Brauhn 1975). Rainbow trout eggs contaminated with 0.090 µ/g of a DOT complex and 0.390 µg/g of PCBs (as Aroclor 1242) resulted in 60-70% of the fry developing deformities and 75% cumulative mortality 25 days after hatching. Concentrations of organochlorides required to affect white sturgeon reproduction and egg and fry survival are not known. Successful reproduction does occur in the lower Columbia River, where ova samples from two sturgeon contained 0.16 and 0.45 µg/g PCB (as Aroclor 1254); 0 and 0.47 µg/g DOT; 0 and 0.71 µg/g ODD; and 0.07 and 1.75 µg/g DDE (Bosley and Gately 1981). Those levels generally spanned the range of concentrations found in Kootenai River sturgeon. Gamete viability tests coupled with additional contaminants analysis in 1990 should provide more insight regarding the effects contaminants have on reproduction of white sturgeon in the Kootenai River.

## Movement and Habitat Use

### Seasonal Movement

Because several sturgeon in our study did respond to large changes in flow, the impact that Libby Dam has on downriver discharge may play a role in altering the timing of migration behavior, especially as it relates to spawning (Figure 14). Spawning activity and egg deposition were detected in the lower Columbia River as discharge and temperature increased during May through June (Nigro 1989). Seasonal movement patterns of sturgeon in the Kootenai River appeared to be random in distance and direction travelled. During the fall, fish sought deep holes in the river or migrated downstream to Kootenay Lake. Curiously, fish did not remain in the B.C. river section (rkm 125 to 152), a stretch with numerous deep holes, for extended periods of time. Four fish captured in this stretch did receive transmitters. Galbreath (1985) also reported random sturgeon movement from a study that found no set migrational movement patterns from 1,141 sturgeon tagged and recaptured in the lower Columbia River from 1976 through 1983.

Seven of the sturgeon we tracked exhibited at least one episode of long distance (>67 km) sustained directional movement. The remaining fish did not exhibit such sustained movement, however, absolute maximum distances they travelled ranged from 11 to 58 km. Coon et al. (1977) reported that of 23 sturgeon (>183 cm TL) recaptured in the mid-Snake River, four moved downstream, three moved upstream, two showed multidirectional movement, and 14 were found in the original holes after 362 days at large.

Water temperature could be an important factor involved in sturgeon movement. Haynes et al. (1978) reported that sturgeon movement (>2 km up or downstream) in the mid-Columbia River was primarily a function of temperature, and major movements ceased below 13°C. Sturgeon in the Kootenai River continued to exhibit movement below 13°C, moving as much as 6 km in 6°C water.

Bajkov (1951) reported that sturgeon usually congregate in deep holes during cold winter months and move into shallower water as spring approaches.

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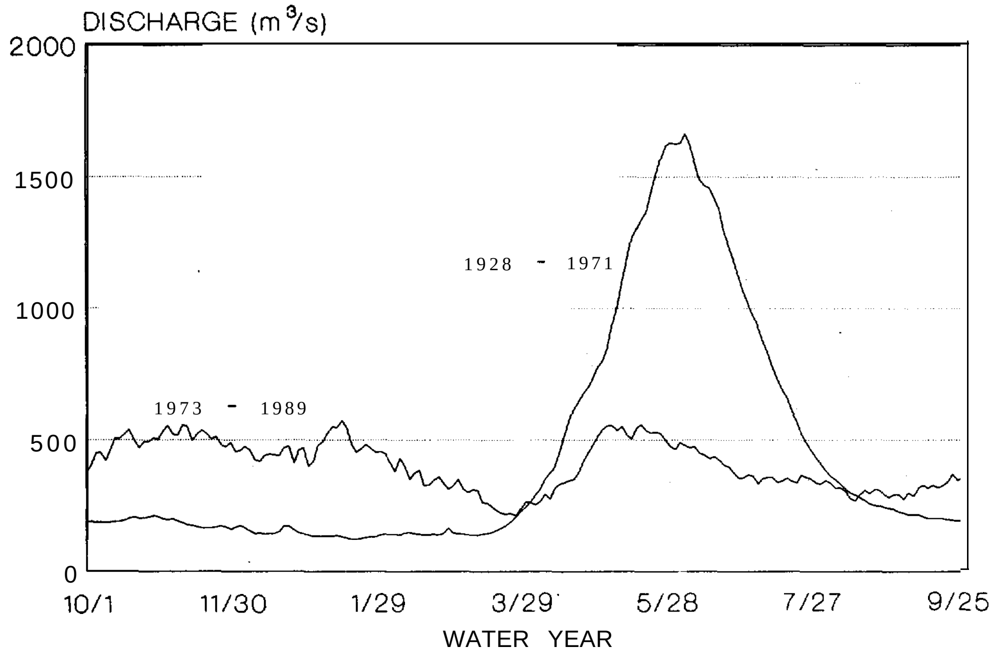


Figure 14. Mean daily discharge in the Kootenai River at Copeland, Idaho prior to and since operation of Libby Dam.

Data from Kootenai River sturgeon suggest a similar trend. As many as ten fish remained in, or travelled between, the deepest holes, in the middle Idaho section of the river (rkm 215 to 246) during late fall and winter, generally inhabiting depths of 12 to 21 m, while fish in this section travelled more widely during summer and early fall.

We know that some migration occurs between the more typical sturgeon habitat downstream from Bonners Ferry and higher gradient waters upstream into Montana. Two sturgeon tagged in Montana (rkm 311) in 1978 were recaptured by anglers near Bonners Ferry (rkm 246) in the spring of 1980 (Graham 1981).

## Diel Movement

Based on diel movement data recorded from six fish for 24 hours at hourly intervals during the summer, sturgeon appear to inhabit water deeper than 12 m when remaining relatively sedentary, while fish found in shallower water generally exhibited more sustained and extensive movements. Coon et al. (1977) recorded locations of two sturgeon (220 cm TL) equipped with sonic transmitters at approximately 2-hour intervals in the mid-Snake River between August 20 and 22, 1973. One of these fish moved only within a large eddy directly downstream of its release site. During both days and nights, this fish moved primarily into the shallower upstream end of the hole, and near daylight both days it appeared to settle back near the area of maximum depth; however, during no 2-hour period did this fish appear to remain completely motionless. The second fish exhibited similar movements in a different eddy after moving downstream through a short rapids following its release. The locations of six sturgeon recorded hourly for 24-hour periods in the Kootenai River also suggests that these fish rarely remained completely motionless. Four of these fish also moved only within the holes of their initial location.

Haynes and Gray (1981) reported that diel movements of sturgeon may be influenced by the light cycle and by feeding requirements. We observed no such diel patterns of movement with respect to orientation in the river channel (ie., inshore versus offshore) .

## Habitat Use

Six fish exhibited major movement during the period of increased turbidity and water level fluctuation, while only three fish exhibited such movement prior to that event. It is difficult to isolate the effects of turbidity from those of changes in river flow. Turbidity and temperature conditions throughout the water column were homogeneous at any given time between Bonners Ferry and Kootenay Lake. Variation in turbidity and temperature utilization frequencies by sturgeon appeared to be due to the flow regime and not due to selection by the fish. Current velocity and water depth are also controlled to varying degrees by Libby Dam operation, but available ranges of these parameters were not limited by any flows.

Habitat use and seasonal movement is dependent upon habitat availability and may dictate whether a white sturgeon in any given locale will move in response to a changing environment or remain in an area that may offer a large range of microhabitats. Before we can hope to clearly understand sturgeon movement and habitat use in the Kootenai, we must, through instream modeling, gain more knowledge regarding habitat availability.

## ACKNOWLEDGEMENTS

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Technical assistance, as well as the velocity meter and turbidimeter, were provided by Al Scholz of Eastern Washington University.

Am Test, Inc. of Redmond, Washington analyzed contaminant content of samples. Ann Setter and Ernie Brannon of the University of Idaho conducted electrophoretic analysis and provided information from lower basin sturgeon stocks for comparison.

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## APPENDIX A.

Report on Kootenai River white sturgeon electrophoretic studies - 1989.

# REPORT ON KOOTENAI RIVER WHITE STURGEON ELECTROPHORETIC STUDIES – 1989

Prepared for
Idaho Dept. Fish & Game

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Aquaculture Extension
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## Kootenai River White Sturgeon - 1989

### Examination of muscle tissue using Starch Gel Electrophoresis to determine the extent of genetic differentiation from Columbia River White Sturgeon

The opportunity to examine more individuals from the white sturgeon population in the Kootenai R. was sought in order to provide a more complete genetic description of the population. In 1987, nine individuals were sampled for muscle tissue and the electrophoretic data obtained was used to formulate a preliminary identification for the population. The data obtained suggested that the Kootenai R. fish stood apart from the rest of the Columbia R. sturgeon by the lack of variability noted from the isozyme data. In 1989, 56 more sturgeon samples were taken by the IDFG white sturgeon research group for electrophoretic analysis. Muscle tissue was again taken from below the dorsal fin area by using a cork borer.

The tissue was placed in a marked test tube, put into a labeled whirlpak bag and immediately frozen on dry ice. Samples were then transferred on dry ice on a weekly basis to the University of Idaho. The tissue samples were then prepared for analysis by adding 0.2 ml of PTP, a tissue dilution buffer which enhances activity in some of the enzyme stains examined. The tissue was held in a supercold (-80 C) freezer until analysis. Starch gels were routinely prepared the day before use. Recipes for stains were taken from Aebersold et al (1987). Methods used were standard for horizontal starch gel electrophoresis in fish and have been described in greater detail by Setter (1988).

The results from the 1989 genetic population survey altered the conclusions we had-reached with our preliminary data set collected in 1987. The database is now comprised of information from 65 individuals and the error in extrapolating conclusions is significantly reduced from those reached in 1987.

After examining these additional white sturgeon we find that our estimate of average heterozygosity for the population has changed substantially from 0.028 to 0.054 which brings it much closer to the 0.74 observed for the Columbia R. where over 600 individual sturgeon have been examined.

Average heterozygosity is a measure of the quantity of genetic variation and is often given as an H value. H represents the percentage of loci heterozygous in the average individual from a population. The present calculated value for H we feel would hold up with continued sampling and therefore we can conclude that the amount of variability is on the average less for individuals found in the Kootenai R. than those found throughout the Columbia R. This may not however be worth preserving as the reduction of individual genetic variation may be more of a liability than an asset.

Genetic variability is the basis for long term evolutionary change. When a population becomes isolated from any new gene flow, gradual genetic differences are expected to occur. The genetic differentiation brought on by specific environmental circumstances can create distinct subpopulations within a species. The maintenance of this genetic integrity complicates management of fishery resources by mandating some form of conservation and enhancement when stock sizes dwindle due to overharvest or habitat alterations. Due to the extensive habitat changes associated with the construction of Libby dam and the fact that Kootenai R. white sturgeon have been geographically isolated since the last glacial age, concern about preservation of any genetic differentiation that may have adaptive significance is critical. Our results, which show a lowered average heterozygosity (less genetic variation) and a number of enzyme systems which do not exhibit the variation found in the Columbia R.; suggest that genetic discreteness does exist for this group of fish.

Twenty-four enzymes were used in this examination comparing genetic diversity between the Columbia and Kootenai rivers. In the Kootenai R., nine of these systems were polymorphic while in the Columbia seventeen of these enzymes-displayed genetic variation. A chi square goodness of fit test was performed using genotype frequencies to test if the population is in Hardy Weinburg equilibrium.

The allele frequency data (Table 1) shows the enzymes where variation occurred in both the Kooootenai and Columbia Rivers. Five enzymes were noted where no variation was evident in the Kootenai River. This is obvious in the allele frequency data table because there are no frequencies for the B allele and a 1.0 for the allele. Two of these systems, MDH-1 and PGM-1 are both polymorphic in ail other areas of the Columbia River examined. This fact lends strength to the argument that this population has lost genetic variation since becoming geographically isolated.

Genetic distance was calculated using the unbiased method of Nei (1978) from allele frequencies. The calculated distance "of the Kootenai from the Columbia river was 0.03. This value falls within the mean range of 0.02-0.06 for stock differences within a species.

Contingency chi square analyses were performed between the two populations and rejection values $X^2_{.05,1} = 3.841$ are used to determine where significant differences in heterogeneity exist between these populations. Seven systems showed a significantly different degree of variation (AAT-1, ALD-1, GAP-1, GPI-2, LT-3, MDH-1, PGM-1).

As a result of our numerous analyses of the combined 1987-1989 Kootenai R. white sturgeon tissue samples, we find adequate evidence to distinguish these fish as a separate population based on differences in allele frequencies, the genetic distance calculation and the overall quantity of variation displayed. This information should prove important for management decisions based on the genetic integrity of this reproductively isolated population of white sturgeon.

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Table 1. Allele frequencies for Columbia (1) and Kootenai (2) Rivers.

| | Population | | | Population | | | Population | |
|---|---|---|---|---|---|---|---|---|
| Locus | 1 | 2 | Locus | 1 | 2 | Locus | 1 | 2 |
| AAT-1 | | | EST-1 | | | LT-1 | | |
| (N) | 586 | 65 | (N) | 669 | 65 | (N) | 643 | 58 |
| A | .900 | 1 .000 | A | 1 .000 | 1 .000 | A | .958 | .897 |
| B | .100 | 0.000 | | | | B | .042 | .103 |
| ADA-1 | | | EST-2 | | | LT-3 | | |
| (N) | 337 | 65 | (N) | 116 | 1 | (N) | 269 | 50 |
| A | 1 .000 | 1 .000 | A | .836 | 1 .000 | A | .942 | .880 |
| | | | B | .134 | 0.000 | B | .056 | .120 |
| | | | C | .030 | 0.000 | C | .002 | 0.000 |
| ADA- 2 | | | GAP-1 | | | MAN-1 | | |
| (N) | 338 | 65 | (N) | 624 | 64 | (N) | 386 | 1 |
| A | 1 .000 | 1.000 | A | .994 | .953 | A | 1 .000 | 1 .000 |
| | | | B | .006 | .047 | | | |
| AH-1 | | | GD-1 | | | MDH-1 | | |
| (N) | 493 | 57 | (N) | 466 | 65 | (N) | 602 | 65 |
| A | .915 | .877 | A | .952 | .985 | A | .925 | 1 .000 |
| B | .082 | .123 | B | .048 | .015 | B | .074 | 0.000 |
| C | .003 | 0.000 | | | | C | .001 | 0.000 |
| AK-1 | | | GPD-1 | | | MDH-2 | | |
| (N) | 620 | 62 | (N) | 650 | 60 | (N) | 561 | 65 |
| A | .985 | 1 .000 | A | .975 | .950 | A | 1 .000 | 1 .000 |
| B | .015 | 0.000 | B | .025 | .050 | | | |
| ALD-1 | | | GPI-1 | | | ME-1 | | |
| (N) | 578 | 65 | (N) | 651 | 65 | (N) | 666 | 65 |
| A | .902 | .838 | A | .987 | 1 .000 | A | .993 | 1 .000 |
| B | .096 | .162 | B | .013 | 0.000 | B | .005 | 0.000 |
| C | .002 | 0.000 | | | | C | .002 | 0.000 |
| CK-1 | | | GPI-2 | | | PGD-1 | | |
| (N) | 626 | 65 | (N) | 643 | 65 | (N) | 437 | 54 |
| A | .999 | 1.000 | A | .849 | .915 | A | .966 | 1.000 |
| B | .001 | 0.000 | B | .151 | .085 | B | .034 | 0.000 |
| CK-2 | | | IDH-1 | | | PGM-1 | | |
| (N) | 598 | 57 | (N) | 488 | 57 | (N) | 640 | 65 |
| A | 1.000 | 1.000 | A | 1.000 | 1.000 | A | .934 | 1.000 |
| | | | | | | B | .061 | 0.000 |
| | | | | | | C | .005 | 0.000 |
| CK-3 | | | LDH-1 | | | PGM- 2 | | |
| (N) | 333 | 1 | (N) | 678 | 65 | (N) | 677 | 65 |
| A | .880 | 1.000 | A | .875 | .892 | A | 1.000 | 1.000 |
| B | .108 | 0.000 | B | .125 | .108 | | | |
| C | .009 | 0.000 | | | | | | |
| D | .003 | 0.000 | | | | | | |
| SOD-1 | | | | | | | | |
| (N) | 441 | 1 | | | | | | |
| A | 1.000 | 1.000 | | | | | | |

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